NWS-TDL-ON-80-9

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
SYSTEMS DEVELOPMENT OFFICE
TECHNIQUES DEVELOPMENT LABORATORY

TDL Office Note 80-9

VERIFICATION OF MOS, PE, AND LFM QUANTITATIVE PRECIPITATION FORECASTS FOR THE 1979-80 COOL SEASON

Edward A. Zurndorfer

December 1980

VERIFICATION OF MOS, PE, AND LFM QUANTITATIVE PRECIPITATION FORECASTS FOR THE 1979-80 COOL SEASON

Edward A. Zurndorfer

1. INTRODUCTION

An objective system based on Model Output Statistics (MOS) (Glahn and Lowry, 1972) to forecast the probability of precipitation amount (PoPA) and categorical amounts has been operational since February 1975. Forecasts of the probability of ≥ .25, ≥ 50, ≥ 1.00, and ≥ 2.00 inches together with a categorical amount are made twice daily for various projections from the 0000 and 1200 GMT runs of the Limited-area Fine Mesh (LFM) model (Gerrity, 1977). Development of the PoPA system is described in detail by Bermowitz and Zurndorfer (1979) and National Weather Service (1980).

As described by Zurndorfer (1980a), a verification program comparing MOS, LFM, and Primitive Equation (PE) (Shuman and Hovermale, 1968) quantitative precipitation forecasts (QPF) has existed since 1976. Zurndorfer (1980a) compared the verification statistics for the 3 models for the period 1975-79 for both the warm (April-September) and cool (October-March) seasons. Generally speaking, the PoPA categorical forecasts were superior to the LFM and PE QPF for the period 1975-79.

In this paper, verification of the MOS, PE, and LFM QPF is presented for the 1979-80 cool season. The scores for the 1978-79 cool season are also shown for comparative purposes.

2. VERIFICATION PROCEDURE

Threat scores[1] and biases[2] were computed for the three models at approximately 230 cities scattered throughout the conterminous U.S. for the categories ≥ .25, ≥ .50, ≥ 1.00, and ≥ 2.00 inches for the projections 12-24, 24-36, and 36-48 h after 0000 GMT.

The LFM and PE QPF were obtained from TDL's collection of grid point fields of these models by interpolating to stations with use of a special algorithm which preserves the integrity of the rain/no rain line (Glahn *et al.*, 1975). PoPA categorical forecasts were retrieved from the operational computer runs. Verifying observations for the 230 cities were obtained from the National Climatic Center in Asheville, North Carolina.

---

[1]Threat score = H/(F+O-H), where H is the number of correct forecasts of a category and F and O are the number of forecasts and observations of that category, respectively.

[2]Bias is the number of forecasts of a category divided by the number of observations of that category. A categorical bias equal to 1 means unbiased forecasts of that category.

3. VERIFICATION RESULTS

Before presenting the results, we mention some of the changes which occurred to the PoPA, PE, and LFM models between the 1978-79 and 1979-80 cool seasons. For the PoPA system, two significant changes were made for the 1979-80 season. First, the derivation of PoPA equations for the projections 24-36 and 36-48 h from 0000 GMT was made with LFM model output as predictors. Previously, due to an inadequate developmental sample of LFM fields beyond hour 24 from model run time, we simply substituted LFM fields for PE fields in PE-based PoPA equations for these projections. We also used the PE threshold probabilities to convert the probability forecasts to categorical forecasts for these projections. Second, an objective technique described by Bermowitz and Best (1979) was used to determine threshold probabilities that maximize the threat score. This objective technique replaced the subjective, iterative method used for the 1978-79 cool season development which is described by Bermowitz and Zurndorfer (1979). Zurndorfer (1980b) compared the two methods and found that the objective one is superior for determining threshold probabilities for PoPA.

One of the more important changes which was made to the LFM-II model between the 1978-79 and 1979-80 cool seasons was implemented with the 1200 GMT run on June 7, 1979. This change consisted of alterations to the convective parameterization scheme which is used in making the model QPF. Details are described in National Weather Service (1979). In short, the old scheme of convective parameterization in the LFM-II resulted in the over-prediction of precipitation during relatively dry circumstances. NMC showed that after this change the LFM-II threat scores increased somewhat and the biases approached unity over the U.S. on five precipitation cases. Thus, it was expected that over-prediction of heavier precipitation amounts would be reduced with this new convective parameterization scheme in the LFM-II.

Results for the projections 12-24 h (first period) 24-36 h (second period) and 36-48 h (third period) are shown in Tables 1-3. The results for the 1978-79 cool season are shown in parentheses for comparative purposes.

From Table 1, it is clear that for the first period there are signs of PoPA deterioration in 1979-80 when compared to the results of 1978-79. It is interesting to note how the PoPA biases have fallen below 1.00 and the threat scores have decreased for each of the four categories. On the other hand, both the LFM and PE have shown some improvement for the $\geq$ .25 and $\geq$ .50 inch categories with larger threat scores and biases closer to unity. However, for the categories $\geq$ 1.00 and $\geq$ 2.00 inches, both models' biases have dropped considerably below unity and the threat scores have also decreased.

The results for the second period shown in Table 2 are similar to those of the first period. With the exception of the $\geq$ .25 inch category, the PoPA threat scores have decreased while the biases have dropped below unity. For the LFM, threat scores have increased and the biases are closer to unity for the $\geq$.25 and $\geq$ .50 inch categories, while for the $\geq$ 1.00 and $\geq$ 2.00 inch categories, there has been a deterioration in both the bias and threat score. The PE showed some improvement in 1979-80 for the $\geq$ .25 inch and $\geq$ 1.00 inch categories in terms of threat score although the $\geq$ 1.00 inch bias is considerably below unity.

Finally, from the third period results shown in Table 3, we see improvement for PoPA for the $\geq$.25 and $\geq$ .50 inch categories as the threat scores increased while the biases approached unity. However, there is evidence of a great deal of underforecasting for PoPA for the categories $\geq$1.00 and $\geq$ 2.00 inches. Also, while there does not appear to be any significant improvement of the LFM threat scores for the categories $\geq$ .25 and $\geq$ .50 inches, the LFM biases are closer to unity. Also, there appears to be deterioration of the PE QPF for the $\geq$.25, $\geq$.50, and $\geq$ 1.00 inch categories with slight improvement for the $\geq$ 2.00 inch category.

4. SUMMARY AND CONCLUSIONS

Verification of PoPA, PE, and LFM QPF for the cool season 1979-80 has been presented. The results indicate some deterioration in PoPA forecasts when compared to those of the 1978-79 cool season. On the other hand, there has been some improvement in the LFM and PE models for forecasting $\geq$ .25 and $\geq$ .50 inches. The LFM forecasts of $\geq$ 1.00 and $\geq$ 2.00 inches have deteriorated with much underforecasting of these events.

Since the PoPA forecasts are based on LFM model output and the LFM precipitation amount is the most important predictor in our PoPA regression equations (National Weather Service, 1980), we were interested in the effect, if any, of the LFM model change in the convective parameterization on the PoPA forecasts. Tables 4-6 present the total number of forecasts made by the LFM for various precipitation amounts. Note that the total number of forecasts for each interval are given for both the 1978-79 and 1979-80 cool seasons.

From Tables 4-6, it is apparent that the LFM did indeed make fewer forecasts of the heavier precipitation amounts in the 1979-80 cool season than in the 1978-79 cool season. This was true for all three periods for which we did the comparative verification. Since the LFM tended to forecast lower precipitation amounts on the average in 1979-80 than in 1978-79, we are not surprised that the PoPA forecasts were also lower on the average for each of the four categories (results not shown). Therefore, PoPA forecasts tended not to exceed the threshold probabilities as much resulting in fewer forecasts of all categories and lower biases.

Other guidance products in which the LFM precipitation amount is an important predictor, such as the probability of precipitation (PoP) and the probability of heavy snow (POSH), may have also had low biases in the 1979-80 cool season. In future PoPA development, we will use cool season 1979-80 and subsequent years as part of the developmental sample; we hope this will result in biases being closer to unity.

REFERENCES

Bermowitz, R. J. and E. A. Zurndorfer, 1979: Automated guidance for predicting quantitative precipitation. Mon. Wea. Rev., 107, 122-128.

______, and D. L. Best, 1979: An objective method for maximizing threat score. Preprints Sixth Conference on Probability and Statistics in the Atmospheric Sciences, Banff, Amer. Meteor. Soc., 103-107.

Gerrity, J. F., 1977: The LFM model—1976: A documentation. NOAA Technical Memorandum, NWS NMC-60, NOAA, U.S. Department of Commerce, 68 pp.

Glahn, H. R. and D. A. Lowry, 1972: The use of Model Output Statistics (MOS) in objective weather forecasting. J. Appl. Meteor., 11, 1203-1211.

______, G. W. Hollenbaugh and F. T. Globokar, editors, 1975: Computer programs for the MOS development system IBM 360/195 version. TDL Office Note 75-2, National Weather Service, NOAA, U.S. Department of Commerce, (MOS OP NO. 58).

National Weather Service, 1979: Modifications of the seven layer LFM model. NWS Technical Procedures Bulletin No. 265, National Weather Service, NOAA, 3 pp.

______, 1980: The use of Model Output Statistics for predicting the probability of precipitation amount and precipitation amount categories. NWS Technical Procedures Bulletin No. 283, National Weather Service, NOAA, 12 pp.

Shuman, F. G. and J. B. Hovermale, 1968: An operational six-layer primitive equation model. J. Appl. Meteor. 7, 525-547.

Zurndorfer, E. A., 1980a: A comparative evaluation of PE, LFM, and probability of precipitation amount quantitative precipitation forecasts for the period 1975-1979. Preprints Eighth Conference on Weather Forecasting and Analysis, Denver, Amer. Meteor. Soc., 19-22.

______, 1980b: A comparison of objective models for deriving threshold probabilities to maximize the threat score. TDL Office Note 80-3, National Weather Service, NOAA, U.S. Department of Commerce, 5 pp.

Table 1. Comparative verification of 12-24 h precipitation amount forecasts prepared (1) objectively with use of MOS PoPA, (2) by the LFM model, and (3) by the PE model. Scores presented are average scores for 230 stations for the cool season 1979-80. The scores for the 1978-79 cool season are shown in parentheses.

Verification Score	Category (inch) ≥.25			≥.50			≥1.00			≥2.00		
	PoPA	LFM	PE	PoPA	LFM	PE	PoPA	LFM	PE	PoPA	LFM	PE
Threat Score	.326 (.344)	.321 (.295)	.315 (.307)	.248 (.279)	.259 (.222)	.230 (.228)	.117 (.167)	.101 (.134)	.092 (.145)	0.0 (.113)	.026 (.037)	0.0 (0.0)
Bias	0.85 (1.22)	1.21 (1.54)	1.18 (1.57)	0.70 (1.26)	1.00 (1.50)	0.87 (1.41)	0.33 (1.24)	0.49 (1.18)	0.30 (0.93)	0.03 (1.57)	0.05 (0.22)	0.05 (0.22)
Number of Cases	1810(1908)			974(878)			264(233)			38(23)		

Table 2. Same as Table 1 except for the 24–36 h projection.

Verification	Category (inch)											
	$\geq .25$			$\geq .50$			≥ 1.00			≥ 2.00		
Score	PoPA	LFM	PE	PoPA	LFM	PE	PoPA	LFM	PE	PoPA	LFM	PE
Threat Score	.309 (.273)	.290 (.256)	.261 (.258)	.207 (.213)	.211 (.193)	.175 (.195)	.058 (.105)	.057 (.117)	.065 (.060)	0.0 (*)	0.0 (.045)	0.0 (0.0)
Bias	1.09 (1.56)	1.30 (1.57)	1.15 (1.54)	0.92 (1.70)	1.33 (1.62)	1.01 (1.46)	0.31 (2.06)	0.94 (1.55)	0.52 (0.80)	0.04 (*)	0.12 (0.31)	0.0 (0.06)
Number of Cases	1941(2040)			869(939)			238(255)			25(35)		

*No equation for this category in 1978–79.

Table 3. Same as Table 1 except for the 36-48 h projection.

Verification Score	≥.25 PoPA	≥.25 LFM	≥.25 PE	≥.50 PoPA	≥.50 LFM	≥.50 PE	≥1.00 PoPA	≥1.00 LFM	≥1.00 PE	≥ 2.00 PoPA	≥ 2.00 LFM	≥ 2.00 PE
Threat Score	.240 (.215)	.218 (.219	.188 (.232)	.165 (.132)	.151 (.150)	.125 (.173)	.042 (.051)	.072 (.058)	.059 (.065)	0.0 (*)	.028 (0.0)	.024 (0.0)
Bias	1.12 (2.22)	1.36 (1.63)	1.33 (1.71)	0.85 (2.29)	1.11 (1.52)	1.03 (1.52)	0.35 (2.78)	0.74 (1.19)	0.64 (0.86)	0.18 (*)	0.05 (0.29)	0.26 (0.04)
Number of Cases	1706(1943)			813(909)			239(249)			34(24)		

*No forecasts for this category in 1978-79.

Table 4. Number of quantitative precipitation forecasts made by the LFM model for various amounts for the projection 12-24 h from 0000 GMT. Statistics are for 233 cities throughout the conterminous U.S.

Category (inches)	Number of Forecasts 1978-79	1979-80
≥ .25	2929	2190
≥ .50	1317	974
≥1.00	275	130
≥2.00	5	2

Table 5. Same as Table 4 except for the 24-36 h projection.

Category (inches)	Number of Forecasts 1978-79	1979-80
≥ .25	3202	2523
≥ .50	1521	1156
≥1.00	396	224
≥2.00	11	3

Table 6. Same as Table 4 except for the 36-48 h projection.

Category (inches)	Number of Forecasts 1978-79	1979-80
$\geq$ .25	3167	2320
$\geq$ .50	1382	902
$\geq$ 1.00	297	177
$\geq$ 2.00	7	2